Small and Medium Enterprises' Solution to Improve On-site Waste Management in Office Building Retrofit Projects

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Abstract: Office building retrofit projects are increasingly more intensified as existing buildings are aging. At the same time, building owners and occupants are looking for environmentally sustainable products. These retrofit projects usually take place in center business district (CBDs) with on-site waste becoming one of the critical issues. Small and Medium Enterprises (SMEs) carry out most of the work in retrofit projects as subcontractors. Despite their large involvement, they often do not have adequate resources to deal with the specific technical challenges and project risks related to waste. Few research has been done on their performance of waste management operations. This paper identifies characteristics of on-site waste in office building retrofit projects. It examines the specific requirements for contractors to manage waste in the projects before exploring the existing performance of SMEs. By comparing requirements for SMEs and their potential areas for improvement, a framework is established for performance promotion of SMEs in on-site waste management of office building retrofit projects. The paper will raise the consciousness and commitment of SMEs as sub-contractors to waste management. It also explores ways of supporting SMEs for experience accumulation, performance promotion and project culture establishment towards effective and efficient on-site waste management in the growing sector of office building retrofit and upgrade.

Key words: office building, retrofit, waste management, sustainability

1. INTRODUCTION

The past decade has witnessed increasing needs for office buildings retrofit. Because many existing stock of office buildings is aging, owners and occupants are looking for more energy efficient and environmentally sustainable product. As it is shown in Table 1, the average age of office stock across Australian CBDs is rising, ranging from 25 years in Brisbane to 31 years in Adelaide (AdelaideCityCouncil, 2007).

The environmental impact of retrofit is less than that of demolition and construction projects (BFM. & BRE., 2004), because the materials and components dismantled from the buildings usually contain the potential value of reuse or recycling. Appropriate planning, collection and management of waste from office building retrofit projects will promote waste minimization and resource efficiency on site. During retrofit process, the buildings are often occupied, which result in limited space and short schedule for site work. This brings great challenge to material handling, storage and waste management during the project.

It is estimated that up to 90% of the construction work is carried out by a variety of subcontractors while the main contractor tends to focus on management and coordination (Khalid, Marton, & Steven, 2006). It is usually the same situation in office building retrofit projects, where on-site works are usually divided into small contracts due to the large scale of office buildings (Dulung & Pheng, 2005; Holm, 2000; Quah, 1992). Therefore, the extent of involvement in waste management by subcontractors, which are Small and Medium Enterprises (SMEs), will exert huge impact on site sustainability performance.

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Small business is not a scaled-down version of big business (Redmond, Walker, & Wang, 2008; Thakkar, Kanda, & Deshmukh, 2008). Generally, small businesses tend to have the following management or organizational characteristics (Trewin, 2001):

- Independent ownership and operations;
- Close control by owners/managers who also contribute most to operating capital; and
- Leading decision-making by the owners/managers

These characteristics bring both strength and drawback to SMEs' business operation. The key strengths of SMEs are flexibility, quick decision-making and cooperation from employees, while weaknesses are lack of technical superiority, infrastructural facilities and financial resources (Dangayach and Deshmukh, 2001 as cited in Thakkar, Kanda, & Deshmukh (2008)). SMEs are more cash focused and short-term oriented(Brynjolfsson, 1994 as cited in Thakkar et al.(2008)). Burke & Gaughran (2006) believed that SMEs are under the most strain from modern business demands of having to comply with existing and up-and-coming legislation, reduce costs, meet customer expectations/demands, remain competitive and maintain a good corporate image.

Therefore, SMEs usually comply with the requirements of large companies during their work process of the project, in order to finish the job and get paid. They neither have the motivation nor ability to become highly efficient with waste management issues on project site, because of the lack of resources, including knowledge, capital, technology and time. However, with large contributions made by SMEs to the construction industry, their performance in on-site waste management needs improvement. It will also boost the industry practice and performance for office building retrofit projects. So far, environmental research has mostly concentrated on large firms (Parker, Redmond, & Simpson, 2009). Few research has been conducted in SMEs' perspective to address the issues of project on-site waste handling and management. Little information is available on how small businesses should manage the responsibility (Redmond, et al., 2008; Thompson & Smith, 1991). Waste management performance of SMEs is neither recognized nor evaluated.

Table 1: Average Age of Commercial Building Stock in Australian CBD
(Source: Jones Lang LaSalle, & Cityscope as cited in (AdelaideCityCouncil, 2007))

Market	A Grade		Total Stock	
	Avg.age since construction	Avg.age since construction or last refurbishment	Avg.age since constructio-n	Avg.age since construction or last refurbishment
Sydney CBD	20	13	28	19
Melbourne CBD	19	10	31	17
Brisbane CBD	17	9	25	13
Adelaide CBD	18	14	31	19

This paper identifies the characteristics and patterns of waste produced on site of office building retrofit projects. It examines the specific requirements for contractors for on-site waste management in these projects before exploring the existing performance of SMEs for waste management. By comparing requirements for SMEs with their potential areas for improvement, a solution framework is established for performance promotion of SMEs in on-site waste management of office building retrofit projects.

2. CHARACTERISTICS OF WASTE FROM RETROFIT PROJECTS

BFM. & BRE. (2004) defines retrofit as the removal and replacement of internal fixtures. This process is different from demolition as it does not involve the removal of the structure which underlies the fixtures. However, there are overlaps between retrofit and demolition/ new build as the retrofit process involves:

- Removal of fixtures in a similar manner to the soft strip phase of demolition
- Installation of new fixtures in a similar manner to the first and second fit out stages of new build project

In addition to the particular process of office building retrofit project, previous research has also discovered that waste flow generated from retrofit project is different from new build projects. Effort has been made to establish waste benmarks for both refurbishment and new build project (Thorpe, 2008). Take commercial office for example, average waste amount generated from refurbishment and new build projects in August 2008 is shown in Table 2. It can be noted that refurbishment project generates less waste compared to new build project. Refurbishment project also generates some waste which is more suitable for reuse and recycling, including concrete, electrical equipment and furniture. It indicates the potential to enhance waste reuse and recycling in office building retrofit projects.

Table 2: Waste Benchmark (m^3waste/100m^2) for Refurbishment and New Build of Commercial Office
(Thorpe, 2008)

Waste Description	Project Type	
	Refurbishment	New Build
Canteen/office/adhoc	0.854	1.964
Ceramics/bricks	0.258	0.369
Concrete	0.705	0.556
Electrical equipment	0.557	0.303
Furniture	0.455	0.117
Hazardous	0.005	0.031
Inert	1.655	5.317
Insulation	0.565	1.052
Liquids and oils	0.000	0.002
Metals	0.794	1.400
Packaging	3.404	3.269
Plaster/cement	2.529	1.614
Plastics	0.621	0.575
Timber	1.674	3.568
Total	14.1	20.1

In new build or demolition projects, the path of waste generation, accumulation, transportation and handling is open-ended on project site. In new build projects, materials are transported to the construction site from manufacturer. With the implementation of project, waste is produced, collected, sorted, transported and reused, recycled or dumped off site. In demolition projects, dismantled waste materials are usually moved to recycling center for handling and treatment. Therefore, there is no waste flow cycle occuring on site of new build/demolition project, as shown in Figure 1.

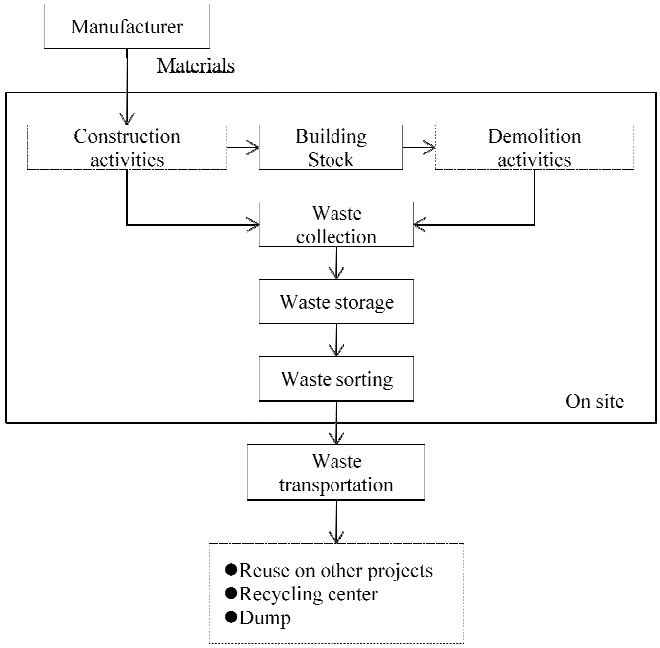

Figure 1: Open-ended Waste Flow in New Build/Demolition Project

In office building retrofit project, it is possible for some materials and components dismantled from the deconstruction stage to be reused. According to the previous research by Miller, Khan, Hardie, & O'Donnell (2006), a certain level of reuse of some categories of waste from office building refurbishment project in Australia has

been achieved, such as hardwood, timber, aluminium, glass, suspended ceilings, partition walls, joinery, workstations, glazed partitions, electrical fittings, carpet, window fittings, sanitary items, mechanical, plumbing generally, refrigeration components. The average reuse rate is around 10%. Therefore, it is possible for some waste generated from office building retrofit project to form an on-site closed cycle flow, as shown in Figure 2.

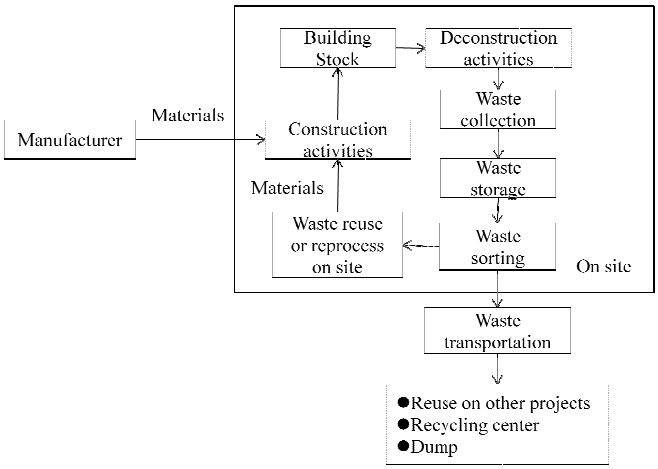

Figure 2: On-site Closed Cycle Waste Flow in Office Building Retrofit Project

3. CONTRACTOR'S ROLES

Because of the differences between office building retrofit projects and new build/demolition projects, there are specific requirements for contractors' performance during the project process.

It is believed that getting a right project team is the most important factor of the outcome of the project. A right team does not only include members with appropriate experience and skills, but also the right chemistry and attitudes. Moreover, the flexibility to respond quickly and decisively to changes and unplanned events typical of such projects is also vital (Charles O. Egbu, 1999; Sanvido, 1991).

Because of the uncertainties related to retrofit projects, the need for contractors to select and control project resources is much stronger than in a new build project (Dulung & Pheng, 2005). With increasing contract labor and arising variations of the work, managers are expected to have the ability of flexible and effective management of information, ability to plan and forecast the amount of project resources, capability of coping with unexpected changes, conflicts and crises and making impromptu decisions when needed. Managers also need skills and knowledge of motivating team workers and building the recognition of health and safety among all the team members. Interpersonal skills of communication are also essential to make the project run smoothly. (C. O. Egbu, 1997; Charles O. Egbu, 1999).

The literature studies revealed four factors for contractor requirement, including acknowledgement, culture, management and technique. These factors reflect on manager, worker and team to better manage on-site waste. Table 3 shows the requirement matrix for contractors to manage on-site waste in office building retrofit projects.

Table 3: Requirements for Contractors to Manage On-site Waste in Office Building Retrofit Projects

Target	Requirement	Factor			
		Acknowledgement	Culture	Management	Technique
Manager	Flexible and effective management of information			✓	✓
	Integrate waste management activities in the whole project schedule	✓		✓	
	Select and control project resources and contracts			✓	✓
	Plan and forecast the amount of labor, materials and plant resources for the works			✓	✓
	Cope with unexpected changes, conflicts and crises			✓	✓
	Make impromptu decisions when needed			✓	✓
	Interpersonal skills of communication		✓		✓
	Leadership			✓	✓
	Constant supervision of subordinates and co-workers			✓	
	Motivate team workers	✓	✓	✓	
	Build the recognition of health and safety among all the team members	✓	✓		
Worker	Appropriate experience and skills	✓			✓
Team	Formed early and remains together until the end of the project		✓		
	The right chemistry and attitudes of cooperation	✓	✓		
	Flexible and respond quickly and decisively to changes and unplanned events			✓	✓
	Acknowledgement and commitment to promote reuse and establish closed-cycle waste flow on site	✓	✓		✓

4. SMEs' DILEMMA

Waste management is a critical issue for every part of the construction supply chain. It needs every project stakeholders to cooperate with each other to achieve waste avoidance and minimizations during the project delivery. This is because clients, designers, main contractors and subcontractors work together as a unified team rather than as a disparate collection of separate organizations (Briscoe, Dainty, & Millett, 2001; Geoffrey & Andrew, 2005). There is a large number of SMEs, which are the main suppliers of subcontracting work in the construction industry (Briscoe, et al., 2001; John & Peter, 2004), indicating SMEs are exposed to on-site waste generation. It is important for business and community sustainability that small businesses are actively engaged in reducing waste (Redmond, et al., 2008). The improvement of their performance will enhance the effectiveness and efficiency of waste management throughout the project.

Currently, large companies are often the main contractors in waste management, because of the need to conform with code of conduct and building regulations. Actually, large companies usually have recognized and certified environmental management

systems concerning the potential trade and market advantages. However, the system is not suitable for SMEs because they have a smaller turnover and thus a correspondingly small return on the costs of system establishment and certification (Government, 2009). SMEs' acts on work can slip while they operate under main contractors.

The level of recognition of the importance of waste management does vary between large and small businesses (Redmond, et al., 2008). It is found that SMEs place considerably less emphasis on supply chain upstream integration. They are just within an arm length of large companies and abide by their rules (Terje & Morten, 2007). There are widely-held perceptions among all categories of employees (operatives, site management and head office management) in labor-only subcontractors that waste management is not cost-effective and company rewards for effective waste management are lacking (John & Peter, 2004). As a result, there is little cooperation between SMEs as subcontractors and large companies as main contractors in project waste management.

SMEs often have major problems on limited resources, limited knowledge, and limited technical capabilities to deal with their own negative environmental impact (Burke & Gaughran, 2006; Parker, et al., 2009; Redmond, et al., 2008). SMEs' involvement in project on-site waste management is not enough.

No previous research focused on the performance of SMEs in waste management of office building retrofit projects, but Miller et al. (2006) have identified some problems in the current system of waste management in commercial retrofit and the areas where have potential to improve performance:

- Lack of monitoring of waste arising.
- No effective means of planning for waste minimization.
- No contractual arrangements for waste minimization.

These problems indicate that on-site waste management is not well conducted through integration with project delivery. The problems can be rectified by encouraging SMEs, who undertake most of the on-site work, to improve their involvement in on-site waste management in office building retrofit projects. However, there have been no common acknowledgement and practical rules for SMEs to follow in this regard.

Two key factors were perceived to be the barriers of minimizing waste on commercial retrofit (Miller, et al., 2006):

- Time available to complete a retrofit, which is linked with the cost of the project
- The presence of hazardous materials, which can render otherwise recyclable materials as contaminated

Therefore, there is need for project stakeholders, especially SMEs, to develop and improve knowledge and techniques regarding on-site waste management of office building retrofit projects, which can help achieve the whole project objectives, as well as gaining resource and environmental efficiency.

The potential areas for improvement of SMEs from existing research is summarized in Table 4. These issues for improvement can be categorized into the four factors as discussed in the last section, including acknowledgement, culture, management and technique. As discussed before, the four factors are necessary for contractors to satisfy the requirements of managing on-site waste in office building retrofit projects. Therefore, SMEs need to improve each potential area to achieve promotion of the four factors.

Table 4: Potential Areas for SMEs to Improve On-site Waste Management in Office Building Retrofit Projects

Acknowledgement	Low level of recognition of the importance of waste management
	Lack of knowledge of waste management
Culture	No company rewards for effective waste management
	No enough cooperation with large companies
Management	No integration with project delivery
	Lack of management resources and techniques
	No effective means of planning for waste minimization
	Lack of monitoring of waste arising
Technique	Little technical solutions for hazardous materials

5. A FRAMEWORK FOR SMEs

For SMEs to better manage on-site waste and reap the awards, their existing problems have to be resolved and potential areas have to be improved towards more sustainable practices. However, it was argued in previous research that a number of resources had been developed for SMEs both in Australia and internationally to assist them in moving towards more sustainable practices but most had failed to create change in the majority of SMEs (Revell & Rutherfoord, 2003). Some of the barriers to uptake behavioural change in SMEs have been found and summarized in Table 5.

To determine the most effective behavioural change program, four types of interventions are believed to be combined and carried out gradually (Gardner & Stern, 1996):

- Appealing to values with the aim to change broad worldviews and beliefs
- Offering education and information
- Providing incentives either as monetary or recognition for good practice
- Establishing "community norms" or shared rules

To improve potential areas and achieve performance promotion of SMEs in on-site waste management of office building retrofit projects, a framework which enables step-by-step improvement of SMEs' perceptions and practices is necessary. Firstly, it needs SMEs to change attitude and concept of managers and workers towards on-site waste management in office building retrofit projects to raise the importance of the issue in the whole company. Training and education about knowledge of waste management also needs to be offered to managers and workers. Secondly, worked examples of principles, method and technique of on-site waste management in office building retrofit projects need to be established and made widely recognized and accepted in the whole company. Finally, company systems supporting on-site waste management are supposed to be established. The three-step achievement is shown in Figure 3.

Table 5: Barriers to Implement Environmental Change in SMEs
(Source: Condon (2004))

Characteristics	Barriers	Implications
Environmental issues not seen as significant	Lack of understanding of environmental legislation	Not seen as essential to business survival
	Assumed little benefit in cost reduction	Cost savings not realized
	Risk management not considered	Open to litigation
Size of the business	Small numbers of staff with little or no expertise	Difficult to identify issues and solutions
	"Champion" if replaced may mean loss of knowledge and expertise	Loss of expertise
	Lack of resources/time	Insufficient staff to dedicate to environmental or social issues
	Close working relationship with owner or manager	Difficult to maintain anonymity if issues arise
Financial constraints	Expertise too expensive	Generic solutions implemented at lower costs
No management systems	Considered unnecessary	Lack of strategic positioning with no long term view

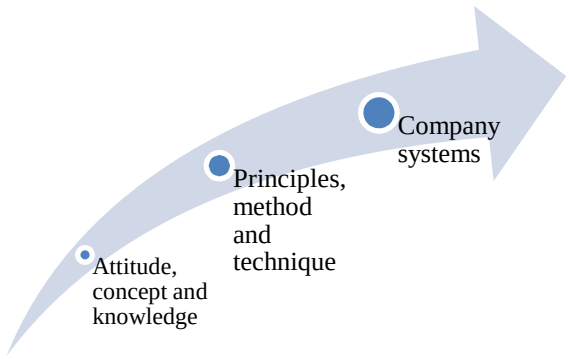

Figure 3: Three-Step Improvement of SMEs in On-site Waste Management of Office Building Retrofit Projects

According to the potential areas for improvement identified in the last section, solutions targeted on each problem can be encapsulated into the three-step improvement to form the framework for SMEs to achieve performance promotion.

- At the first step, education and training are provided for managers and workers to form positive attitude and concept, as well as to gain knowledge related to waste management.
- At the second step, particular principles, method and technique are established concerning the potential of closed-cycle waste flow on the site of office building retrofit project. They may include that waste be treated as the resource rather than by-product of the whole project, the whole process of waste collection, sorting, handling, reprocess and reuse be integrated to project delivery, and that planning of management activities take into account schedule and resource constraints of the entire project. In this way, waste performance is supposed to be considered as equally important as other project performance factors, such as cost, time, quality, etc. Technical manual for appropriate handling of hazardous materials also needs to be established.
- At the final stage, SMEs are supposed to set up company systems to support effective and efficient on-site waste management, including management process, information communication and reward and penalty mechanism.

The framework is shown in Table 6. This initial concept framework will be further developed during the three-year PhD candidature to provide SMEs with practical guidelines to achieve performance improvement in on-site waste management of office building retrofit projects.

Table 6: Framework for SMEs to Achieve Performance Promotion

Step	Solution	Targeted Problem	
Attitude, concept and knowledge	Provide education and training for managers and workers	Low level of recognition of the importance of waste management	Acknowledgement
		Lack of knowledge of waste management	
Principles, method and technique	Treat waste performance together with other project factors	No integration with project delivery	
	Manage waste as project resource ad encourage waste reuse and reprocess on site	Lack of management resources and techniques	Management
	Plan for waste management based on project schedule and resource constraints	No effective means of planning for waste minimization	
	Establish manual for appropriate handling of hazardous materials	Little technical solutions for hazardous materials	Technique
Company systems	Establish system for waste collection, sorting and recording	Lack of monitoring of waste arising	Management
	Establish communication channel both in and out of company	No enough cooperation with large companies	Culture
	Establish mechanism of reward and penalty	No company rewards for effective waste management	

6. CONCLUSIONS

Office building retrofit is different from new build/demolition projects particularly in the development process respect. The two stages of the project make it possible to form a closed cycle waste flow on site. This cycle involves direct reuse of the waste materials generated from deconstruction at the second stage of constructing new building components. This practice can effectively minimize on-site waste of office building retrofit projects, as well as improve

resource efficiency and provide environmental benefit. Specific qualities concerning managers, workers and project team, are required for contractors to better participate in on-site waste management. However, the current performance of SMEs, which take up most work in the construction industry, is insufficient in several areas, including acknowledgement, culture, management and technique. Possible solutions to rectify each problematic area are needed as discussed in this paper. A framework is established as a guideline to promote performance of SMEs in on-site waste management of office building retrofit projects.

This ongoing research will raise the consciousness and commitment of SMEs as sub-contractors for waste management and on-site reuse. It also explores ways of supporting SMEs for data recording, experience accumulation, performance promotion and project culture establishment towards better on-site waste management in the growing sector of office building retrofit and upgrade. Further support is needed to facilitate better involvement of SMEs in on-site waste management of office building retrofit projects.

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